

Feb. 10, 1959

C. S. SMITH ET AL

2,872,907

MULTIPLE FURNACE VAPOR GENERATOR WITH UNITARY REHEATER
AND SUPERHEATER CONTROL BY GAS RECIRCULATION

Filed March 9, 1953

3 Sheets-Sheet 1

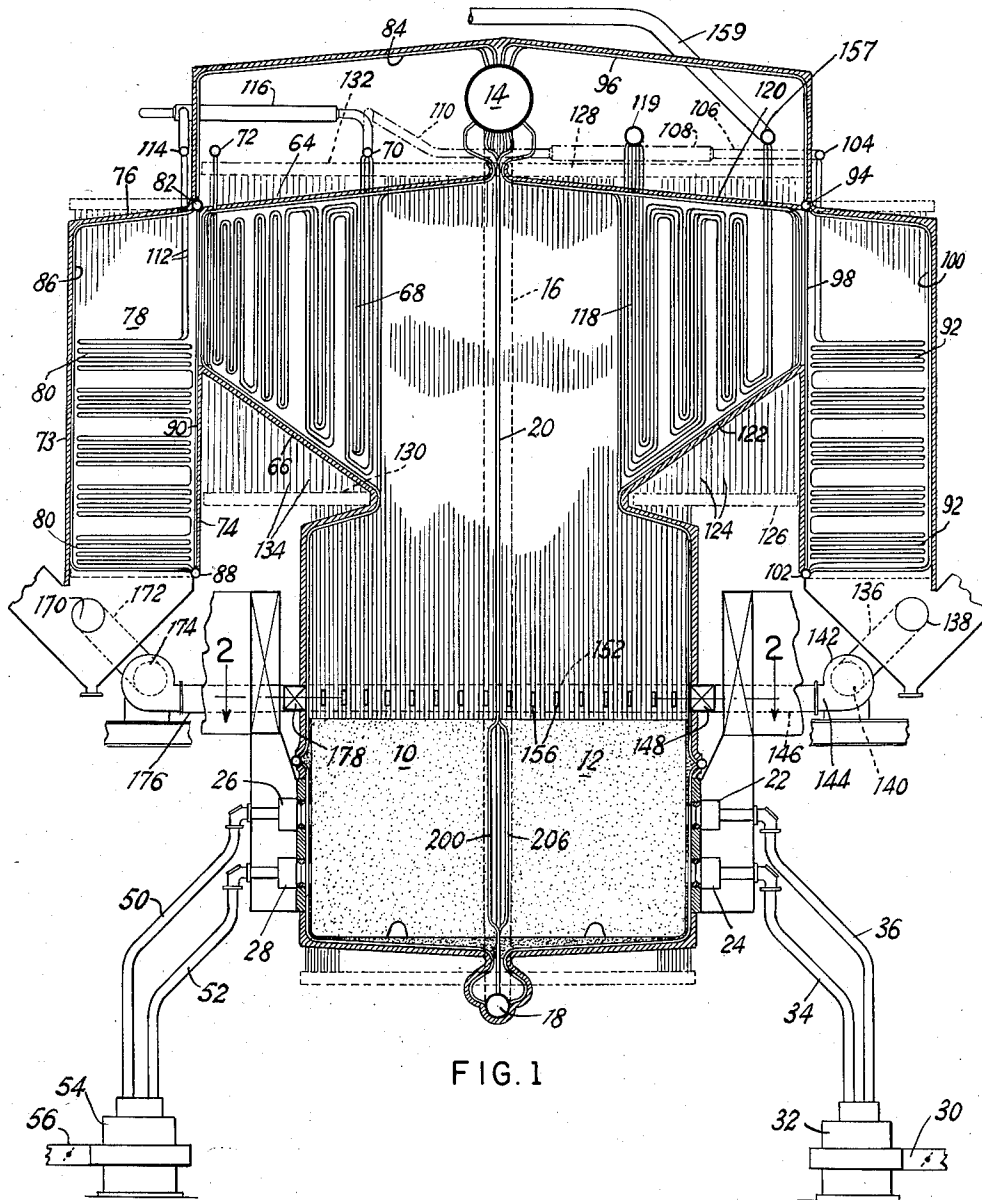


FIG. 1

INVENTORS

Charles S. Smith
Charles H. Woolley, Deceased
by Margaret S. Chamberlin,
Executrix

BY

R. Holbrook
ATTORNEY

Feb. 10, 1959

C. S. SMITH ET AL.

2,872,907

1957 C. S. SMITH ET AL. 2,872
MULTIPLE FURNACE VAPOR GENERATOR WITH UNITARY REHEATER
AND SUPERHEATER CONTROL BY GAS RECIRCULATION

AND
Filed March 9, 1953

3 Sheets-Sheet 2

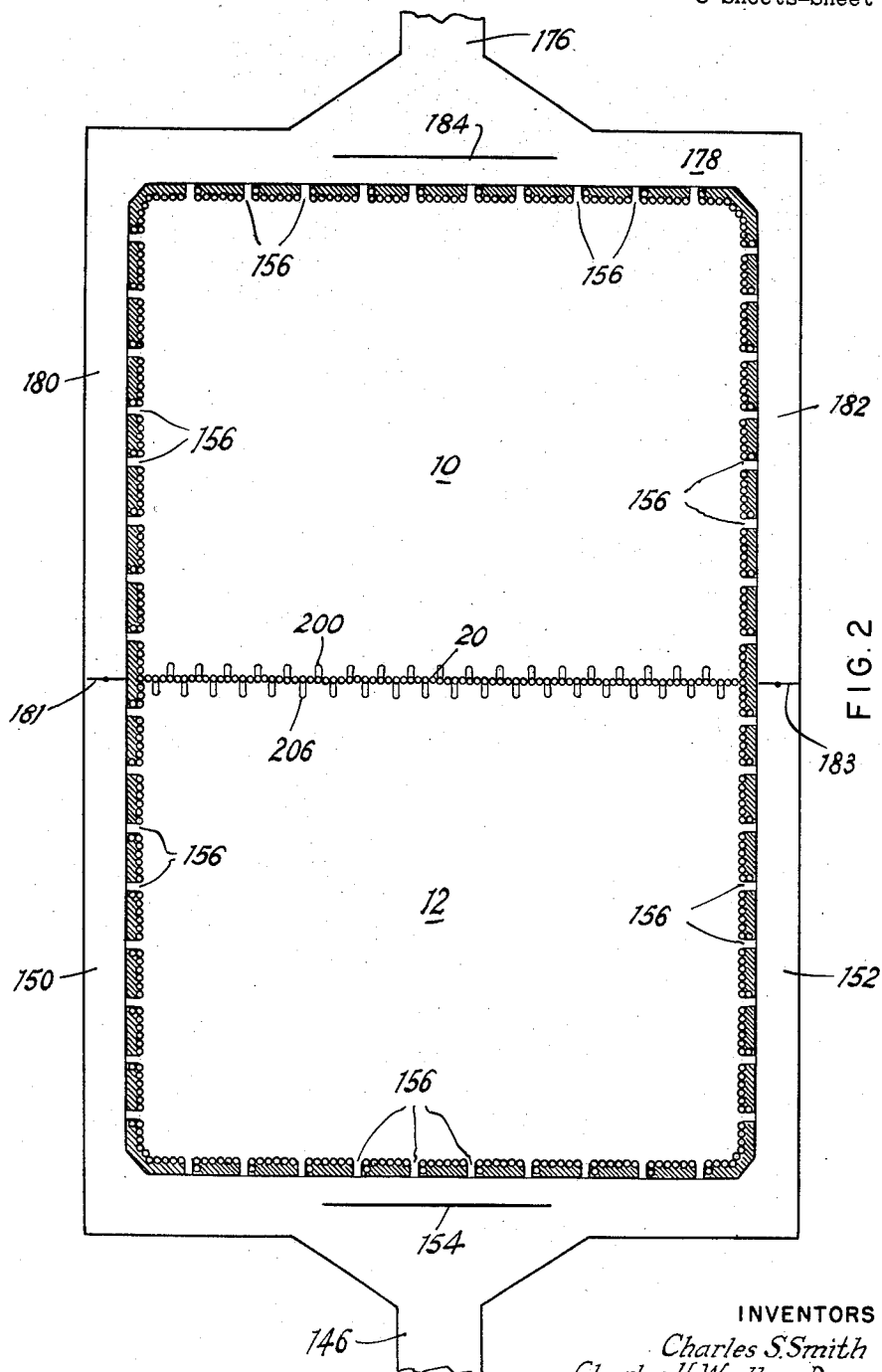


FIG. 2

INVENTORS

Charles S. Smith
Charles H. Woolley, Deceased
by Margaret S. Chamberlin,
Executrix

BY W. Helbrook
ATTORNEY

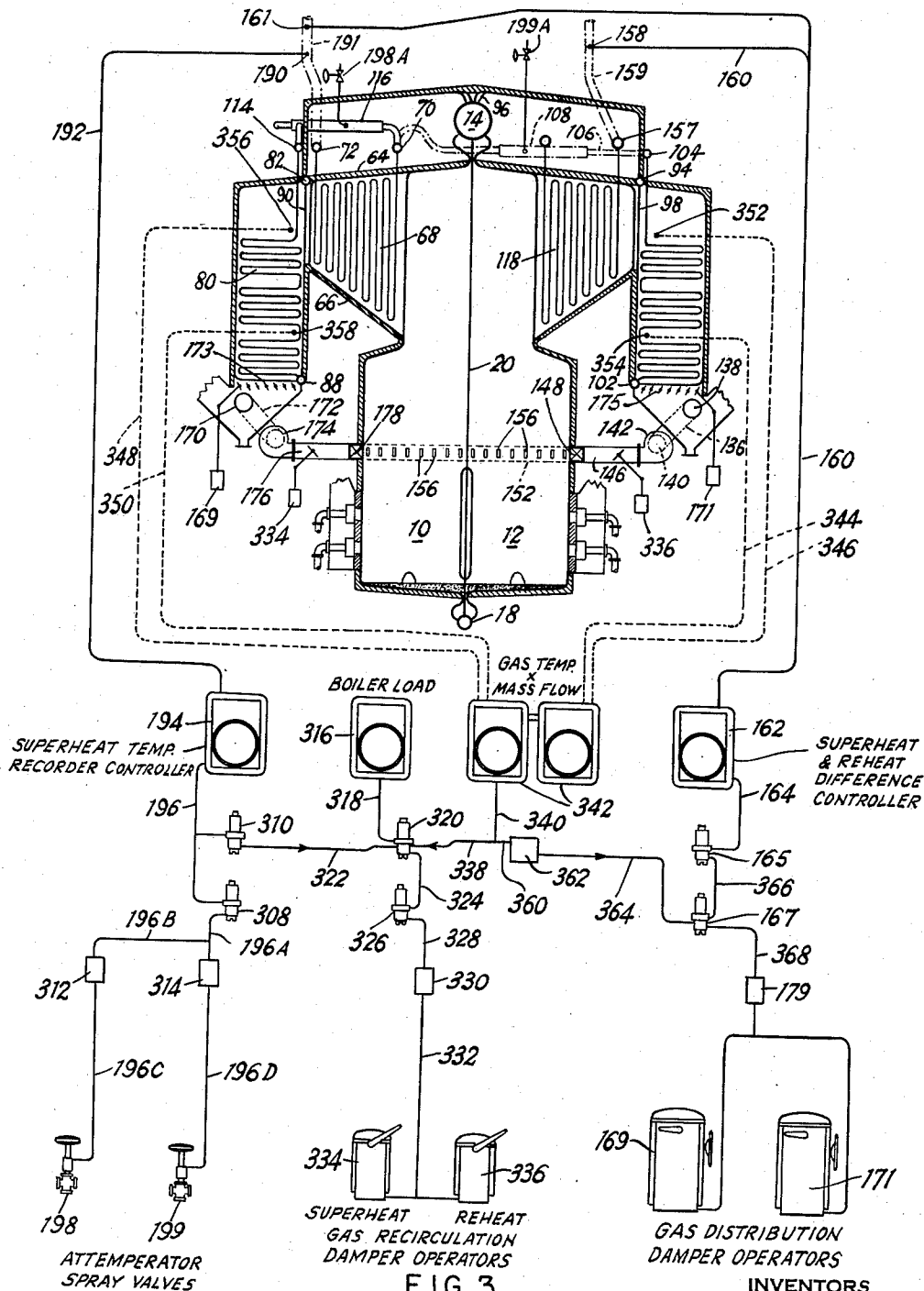
Feb. 10, 1959

C. S. SMITH ET AL
MULTIPLE FURNACE VAPOR GENERATOR WITH UNITARY REHEATER
AND SUPERHEATER CONTROL BY GAS RECIRCULATION

2,872,907

Filed March 9, 1953

3 Sheets-Sheet 3



INVENTORS
Charles S. Smith
Charles H. Woolley, Deceased
by Margaret S. Chamberlin, Executrix
BY *R. M. Holbrook* ATTORNEY

1

2,872,907

MULTIPLE FURNACE VAPOR GENERATOR WITH UNITARY REHEATER AND SUPERHEATER CONTROL BY GAS RECIRCULATION

Charles S. Smith, Westfield, and Charles H. Woolley, deceased, late of Cranford, by Margaret S. Chamberlin, executrix, Cranford, N. J., assignors to The Babcock & Wilcox Company, New York, N. Y., a corporation of New Jersey

Application March 9, 1953, Serial No. 340,948

2 Claims. (Cl. 122—240)

This invention relates to a twin furnace unit for generating vapor under pressure, superheating the high pressure vapor for delivery to a steam turbine, and reheating vapor of a lower pressure returned from the turbine to a reheater.

In its more specific scope, the invention involves a plurality of separately fired combustion chambers, or furnaces, defined by vapor generating tubes of a vapor generating system common to both combustion chambers, a separate gas pass leading from each combustion chamber, a convection vapor superheater disposed in one of the gas passes, a convection vapor reheater disposed in another of the gas passes, a first gas flow control means involving a first gas recirculation system effective to return partially cooled gases from a position downstream of the reheater to a position within the first of the furnaces and regulating the gas mass flow over the reheater to maintain a predetermined vapor temperature at the outlet of the reheater under varying vapor generating loads, and a second gas flow regulating means involving a second recirculating gas flow system for returning partially cooled furnace gases from a position downstream from at least a part of the superheater to a position within the second or superheater combustion chamber to vary the gas temperature and gas mass flow over the superheater to maintain a predetermined vapor temperature at the outlet of the superheater over a wide range of vapor generating load.

By means of the invention, the different temperature load characteristics of the reheater and superheater are compensated by the differential control of the gas recirculation systems to maintain optimum vapor temperatures at the vapor outlets of the reheater and superheater.

The invention thus provides for the differential absorption of the heat by the superheater and by the reheater by placing them in separately controlled gas streams.

In a load range where the heat of the gases contacting the superheating or reheating surfaces is of such a value as to inherently result in excessive heat absorption by the superheating or reheating surfaces, the invention involves the variation of gas flow distribution over the reheater or superheater to bring outlet vapor temperatures to the desired value or values.

The invention will be described with reference to the accompanying drawings which illustrate a preferred type of vapor generating, superheating, and reheating unit involving the invention.

In the drawings:

Fig. 1 is a somewhat diagrammatic view in the nature of a sectional elevation showing a twin furnace with the gases from a first furnace passing over the convection reheater, and gases of the second furnace passing over a convection superheater;

Fig. 2 is a horizontal section on the plane of the section line 2—2 of Fig. 1; and

Fig. 3 is a diagrammatic view showing a control system for the illustrative vapor generating and superheating unit.

2

The drawings illustrate twin combustion chambers or furnaces 10 and 12 having their boundaries defined by vapor generating tubes of a vapor generating system common to the two combustion chambers. The vapor generating tubes deliver vapor and liquid mixtures to a vapor and liquid drum 14 in which the generated vapor is separated from the liquid, the liquid returning through a large diameter external downcomer 16 to a lower header or drum 18 to which the inlets of the vapor generating wall tubes are connected.

The vapor generating system of the illustrative unit also includes the vapor generating tubes of a division wall 20 separating the combustion chambers 10 and 12. The combustion chambers intercommunicate through the openings in the wall 20 provided by the spaced offset tube sections 200 and 206. These tubes are shown as directly connecting the lower drum 18 with the upper drum 14.

The combustion chambers 10 and 12 are fired by a firing system responsive to the demand for generated vapor. This system includes the pulverized coal burners 22 and 24 for the combustion chamber 12, and burners 26 and 28 for the combustion chamber 10.

The burners 22 and 24 have their firing rates controlled by the control of the flow of primary air through the air inlet conduit 30 of the pulverizer 32 which is connected to the burners by the primary air and fuel conduits 34 and 36. The air flow through the conduit 30 is controlled from vapor demand and pressure.

The burners 26 and 28 for the combustion chamber 10 are similarly connected by conduits 50 and 52 to a pulverizer 54 and the fuel and primary carrier air flow to the burners is governed by the control variation of primary air through the conduit 56, the damper 58 varying this air flow being controlled from representations of vapor flow and vapor pressure.

From the superheater combustion chamber 10 the furnace gases pass laterally through a superheater gas pass having the upper and lower boundaries 64 and 66. Within this gas pass is disposed a secondary high temperature convection superheater 68 formed by upright tubes connected for the series flow of vapor from the intermediate header 70 to the superheater outlet header 72. Beyond the gas pass for the superheater 68, the gases pass to a downflow gas pass having the upright walls 73 and 74 and a roof 76. Immediately upon leaving the superheater 68, the gases turn downwardly in the turning space 78 and pass over the banks of horizontally extending tubes of a primary superheater 80. This primary superheater has an inlet header 82 receiving vapor from the drum 14 through the tubes 84. The vapor divides, in the header 82, some of the vapor proceeding through the tubes 86 down along the rear wall 72 and thence to the header 88. The remainder of the vapor from the header 82 passes through the wall tubes 90 to the header 88. From the header 88, the vapor passes through the tubes of the successive banks of tubes forming the primary superheater 80.

At the other side of the unit there is a second primary superheater 92 including banks of tubes similar to those of the primary superheater construction above described. This primary superheater has an inlet header 94 supplied with vapor by the tubes 96. From this header the vapor flows through the wall tubes 98 and 100 to the header 102 from which the vapor passes through the horizontally extending banks of tubes 92 of the primary superheater. The vapor heated in these banks of tubes passes to the outlet header 104 and thence through the conduit 106 to the attemperor 108 and then from the attemperor through the conduit 110 to the inlet header 70 of the secondary superheater 68.

Similarly, vapor from the primary superheater 80 passes through the outlet tubes 112 to the header 114 and thence through the attemperor 116 to the header 70.

of the superheater 68. The convection reheater 118, having an inlet header 119, is disposed in the gas pass leading to the right from the top of the reheater furnace 12. This gas pass has converging upper and lower walls 120 and 122 and side walls which include the vapor generating tubes 124 leading from the lower header 126 to the upper header 128. This construction of the side walls for the reheater gas pass has a substantial counterpart in the arrangement of the headers 130 and 132 and the connecting tubes 134 for the gas pass of the secondary superheater.

To provide for the maintenance of desired temperatures at the vapor outlets of the superheater and reheater over wide ranges of vapor generating load, the invention involves recirculated gas systems, one for the reheater and the reheater combustion chamber, and another for the superheater and superheater furnace. The gas recirculation system for the reheater and the reheater combustion chamber includes ductwork 136 leading from the recirculated gas inlet 138 to the inlet 140 of a recirculated gas fan 142. The outlet 144 of this fan is connected by ductwork 146 with the front wall duct 148 and through it, with the side wall ducts 150 and 152. Fig. 2 shows the arrangement of these ductwork components, with a distributor baffle 154 disposed in the line of flow from the outlet of the duct 146 to some of the furnace wall outlets 156 for recirculated gas. These outlets are clearly shown as disposed between groups of the furnace wall tubes and distributed along the front and side walls of the combustion chamber 12 at an elevation slightly above the upper burners and the interconnection between the furnaces.

The flow of recirculated gas, to maintain a predetermined vapor temperature at the outlet of the reheater is varied in response to the variation in control factors, one of which is the outlet temperature of the reheated vapor in the reheater outlet conduit 159. As illustrative of a part of a control system, the drawing indicates a thermally responsive element 158 in the conduit 159 leading from header 157 and connected by a control line 160 to a recorder, indicator, and controller of reheat and superheat temperature differences 162, effecting loading pressure variations in a line 164 representative of the differences in temperature of the reheated vapor temperature at 158, and superheated vapor temperature at 161 in the outlet conduit 191 leading from the outlet header 72 of superheater 68. These loading pressure variations, or impulses, are effective through relays 165 and 167 and associated connecting lines 366 and 368 and selector 179, on operators 169 and 171 of the sets of gas distribution dampers 173 and 175. The relays 165 and 167 are similar to that shown in the Gorrie patent or the Dickey patent, identified below. The selector valve 179 permits the selection of automatic or manual operation of the operators 169 and 171.

As representative of a control for the vapor temperature at the outlet of the secondary superheater 68, Fig. 3 discloses a recirculated gas system receiving gas through an inlet 170 disposed beyond primary superheater 80. The gases pass from this inlet through a duct 172 to the inlet of the fan 174 and thence through the duct 176 to the front wall duct 178. From the end of this duct the gases pass to the furnace wall recirculated gas outlets 156 of the side wall ducts 180 and 182 (Fig. 2), the distribution baffle 184 being arranged in the line of a gas flow from the duct 176, in a manner similar to the arrangement of the gas flow distribution baffle 154 relative to the duct 146.

Recirculated gas flow through the fan 174 and thence to the superheater combustion chamber 10 is regulated by a control system including a thermally responsive element 190, in the superheater outlet conduit 191, connected by a line 192 to a superheat temperature indicator-recorder-controller 194, effecting loading pressure variations in lines 196, 196A, 196B, 196C, and 196D, leading to attemperorator water valve operators 198 and 199, controlling the operation of valves 198A and 199A of at-

temperators 116 and 108 for the primary superheaters. Interposed relative to valve operators 198 and 199 and the controller 194 is a relay 308 (of the type shown by the patent to Gorrie—Reissue Patent 21,804 or the Dickey Patent 2,098,913) by which the loading pressure variations in the line components 196A, 196B, 196C, and 196D are regulated to provide the desired sequential operation of gas recirculation and attemperoration, in coaction with the relay 310 and its associated control system components.

Interposed in the above mentioned line components are the manual-automatic selector valves 312 and 314, by which temporary manual operation of control components 198 and 199 may be effected. These selector valves as well as the other selector valves of the present control system are of the type described in the Fitch Patent 2,202,485.

Boiler load index is provided by the recorder controller 316 which is operated by differential pressures on opposite sides of an orifice in the superheated steam flow line 191, acting as a measure of steam flow and effecting representative loading variations in the line 318 leading to the relay 320 which also receives modifying loading pressure variations through the line 322 leading from the relay 310. The latter loading pressure variations are representative of superheated steam temperature variations in the outlet line 191 leading from the superheater outlet header 72. The outgoing (with respect to relay 320) loading pressure variations in the line 324 are the resultants of the incoming loading pressure variations in lines 318, 322, and 338 as determined by the positions of entry of these lines into relay 320 and by the regulating setting of the relay controls or adjustments, and these resultant loading pressure variations are further selectively varied or controlled by the relay 326 from which the loading pressures are transmitted through the line 328, the selector valve 330, and the line 332 to the gas recirculation damper control drive for the superheater 334 and to the reheater gas recirculation damper control drive 336. The damper control drives 336 and 334, as well as 169 and 171 may be of the type shown by the patent to Johnson 2,536,184.

The modifying loading pressures in the line 338 are representative of variations in the product of temperature of the gases passing over the primary superheaters 80 and 92 times the totalized mass flow of gases in the gas passes in which those superheaters are disposed. Such loading pressure variations are transmitted through the line 340 to the line 338 by the action of the recorder-controller 342 which has appropriate connections 344 and 346 to temperature (gas) responsive elements and pressure responsive elements within the down gas pass for the primary superheater 92. The other component of the controller 342 is similarly connected by lines 348 and 350 to similar elements in the gas pass for the primary superheater 80. The line 346 extends from a position 352 at which a pressure responsive element and a temperature responsive element may be disposed with the line 346 a double, or dual line, leading from these two elements to the right hand component of controller 342. The difference between the reactions of the pressure responsive element at 352 and those of a similar pressure responsive element at the position 354 will afford an indication of flow. The lines 348 and 350 connect with similarly responsive elements at the positions 356 and 358, the line 348 being a dual or double line with one part leading to a temperature responsive element and the other part leading to a pressure responsive element, both elements being disposed at the position 356, in the gas pass for primary superheater 80. With a similar pressure responsive element at the position 358, the controller 342 can be influenced by the temperature at 356 and also by pressure differential between positions 356 and 358, the latter being representative of flow rate to effect loading pressure variations in

the line 340, representative of variations in the product of gas temperature times totalized mass flow. Such loading variations, besides being effective upon the control of recirculated gas flow through the control system components 320, 324, 326, 328, 330, 332, 334, and 336, also influence the control of the sets of gas distribution dampers 175 (on the reheater side) and 173 (on the superheater side). To exercise the latter control, the line 360 transmits the loading pressure variations of line 340 to a characterizing relay 362 by which the pressure variations may be regulated, or desirably modified to produce the desired effect on relay 167, the pressure being transmitted to the latter by the line 364. This relay combines the effects of the loading pressures in lines 364 and 366 in a desired manner for transmittal of a resultant loading pressure in the line 368 leading to selector valve 179, and thence to the control drive 169 for the set of dampers 173 on the superheater side of the unit, and to the control drive 171 for the set of dampers 175 for the reheater side of the illustrative unit.

With the illustrative control system, the operation of the attenuators 108 and 116 (or the opening or closing of the attenuator water valves 198A and 199A) is controlled solely from final superheat temperature while the rate of gas recirculation is controlled by three factors, i. e.—

(a) Final superheat temperature (through the connecting line 322);

(b) Boiler load index (from the controller 316); and

(c) The product of gas temperature at the inlets of the primary superheater gas passes times the totalized mass flow through said passes.

The distribution of gas flow from the separate furnace divisions (10 and 12) and through the opposite gas passes for the primary superheaters is controlled from two factors i. e.—

(a) The product of gas temperature at the entrances of the primary superheater gas passes times totalized mass flow in those passes; and

(b) The difference between reheat temperature and final superheat temperature at the outlet of the secondary superheater.

While in accordance with the provisions of the statutes we have illustrated and described herein the best form of our invention now known to us, those skilled in the art will understand that the changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by our claims, and that certain features of our invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. A vapor generating, superheating and reheating unit comprising walls defining a setting, means defining a division wall dividing said setting into side-by-side vertically elongated combustion chambers having laterally extending separate heating gas passes opening through opposite walls of said combustion chambers and extending in opposite directions, a vapor generating section comprising rows of upright vapor generating tubes in said division wall and the combustion chamber walls opposite said division wall and a horizontally arranged vapor and liquid separating drum in the upper part of said unit having its longitudinal axis substantially parallel to the plane of said division wall and arranged to receive vapor and liquid from the upper ends of said rows of vapor generating tubes, a bank of vapor super-

heating tubes in one of said gas passes, a bank of vapor reheating tubes in the other gas pass, a second bank of vapor superheating tubes in said other gas pass downstream of said bank of vapor reheating tubes, vapor conduit means connecting the second bank of vapor superheating tubes to said first bank of vapor superheating tubes, means for independently firing said separate combustion chambers, and means for independently controlling vapor superheat and reheat temperatures comprising means for recirculating heating gases from each of said gas passes at points downstream of said first bank of superheating tubes and said bank of reheating tubes respectively and separately introducing said recirculated gases into the corresponding combustion chambers at points remote from the heating gas pass connection thereto, and means for independently controlling the amount of recirculated gases introduced into each of said combustion chambers.

2. A vapor generating, superheating and reheating unit comprising walls defining a setting, means including vapor generating tubes defining a division wall dividing said setting into side-by-side vertically elongated combustion chambers having laterally extending separate heating gas passes opening through opposite walls of said combustion chambers and extending in opposite directions, a horizontally arranged vapor and liquid separating drum above said setting having its longitudinal axis in vertical alignment with said division wall and arranged to receive vapor and liquid from said division wall tubes, a bank of vapor superheating tubes in one of said gas passes, a bank of vapor reheating tubes in the other gas pass, a second bank of vapor superheating tubes in said other gas pass downstream of said bank of vapor reheating tubes, vapor conduit means connecting the second bank of vapor superheating tubes to said first bank of vapor superheating tubes, means for independently firing said separate combustion chambers, and means for independently controlling vapor superheat and reheat temperatures comprising means for recirculating heating gases from each of said gas passes at points downstream of said first bank of superheating tubes and said bank of reheating tubes respectively and separately introducing said recirculated gases into the corresponding combustion chambers at points remote from the heating gas pass connection thereto, and means for independently controlling the amount of recirculated gases introduced into each of said combustion chambers.

References Cited in the file of this patent

UNITED STATES PATENTS

1,387,463	Broido	Aug. 16, 1921
1,931,948	Armacost	Oct. 24, 1933
1,936,699	Weaver	Nov. 28, 1933
2,298,700	Junkins et al.	Oct. 13, 1942
2,512,677	Raynor	June 27, 1950
2,526,898	Powell et al.	Oct. 24, 1950
2,590,712	Lacerenza	Mar. 25, 1952
2,649,079	Van Brunt	Aug. 18, 1953
2,685,279	Caracristi	Aug. 3, 1954
2,781,746	Armacost et al.	Feb. 19, 1957

FOREIGN PATENTS

504,114	Great Britain	Apr. 14, 1939
---------	---------------	---------------

OTHER REFERENCES

B. & W. Bulletin G 67, of 1949, page 30.